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MANUAL OF TRAINING

ARTILLERY TRAINING

COAST ARTILLERY DRILLS

DRILL FOR DEPRESSION RANGE-FINDERS

1953

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ABBREVIATIONS

The following abbreviations are used in this pamphlet :—

C and R	Curvature and refraction
DRF	Depression range-finder
HW	High water.
OG	Object glass.
OP	Observation post.
OPA	Observation post officer's assistant.
OPO	Observation post officer.
LW	Low water.
RI	Range indicator.

COAST ARTILLERY DRILLS

PART II

PAMPHLET No. 1

DRILL FOR DEPRESSION RANGE-FINDER

CHAPTER 1

EMPLOYMENT AND PARTICULARS

SECTION 1.—EMPLOYMENT

1. The depression range-finder (DRF) is used in coast artillery as the range-finder in short range batteries. It is required to evolve ranges continuously.

2. Modern instruments are provided with gearing which allows the reading of bearings to an accuracy of one minute.

SECTION 2.—METHODS OF TRANSMITTING DATA

1. In a short range battery, ranges are transmitted to the guns by a Watkin mechanical dial or by Magslip transmission.

SECTION 3.—PARTICULARS OF INSTRUMENTS

1. DRFs which may be found in coast artillery are :—

Mark 2*—for heights up to 800 feet—converted Mark 2—maximum range 10,000 yards.

Mark 2**—for heights up to 1,500 feet—converted Mark 2—maximum range 10,500 yards.

Mark 3—for heights up to 1,500 feet—with slow motion traversing gear and minute drum—maximum range 12,000 yards.

Mark 4—as for Mark 3, but maximum range 14,400 yards.

Mark 5—for heights up to 1,800 feet—with slow motion traversing gear and minute drum—maximum range 14,400 yards.

2. The introduction of a minute drum in Marks 3, 4 and 5 enables :—

(*a*) The instrument to be oriented more accurately.

(*b*) Travel to be taken for line in addition to range.

(*c*) The instrument to be used to determine accurate bearings, should this be required.

SECTION 4.—MANUALS OF REFERENCE

1. The theory of vertical base range-finding is dealt with in Coast Artillery Training, Volume 1, 1938, Chapter V.

2. A full description of depression range-finders is given in the Handbook of Artillery Instruments and Range-finders, Part 1, Section 17.

CHAPTER 2

GENERAL DUTIES

SECTION 5.—THE DETACHMENT

1. This chapter summarizes the duties of each man in the detachment. It is intended only as a guide to the instructor, who should use his own words in explaining the various duties to the students.

2. The detachment is required to operate the instrument. The service of the range-finder is divided between them as follows :—

(*a*) **1** follows the target, keeping the crosswires of the telescope accurately laid on the bow waterline.

(*b*) **2** watches the arrow on the slider and calls out the range at the interval ordered. He applies corrections on the slider when corrections to the DRF are ordered by the OPO.

(*c*) **3** operates the range transmitter and applies range spotting corrections on the transmitter.

SECTION 6.—DUTIES OF 1

1. **1** is in command of the detachment and operates the traversing gear and range slider on the instrument to find the bearing and range to the target.

At preparation of stores

2. **1** performs the following duties :—

(*a*) Assisted by **2** and **3** he draws the following stores :—

DRF in its box.
Iris diaphragm.
Rain shade.
Illuminating gear with four spare bulbs.
Binocular attachment with eyeguard.
Two eyecaps with moderating glasses (medium and light).
Object glass cap and pricker.
High power eyepiece.
Low power eyepiece.
4-inch screwdriver (for Mark 3 and upwards).

(*b*) **1** disposes of the stores as follows :—

Mounts the instrument on its pedestal (Sec 10).
Places in the telescope the most suitable eyepiece (Sec 11).
Fixes the binocular attachment to the telescope.
Places the iris diaphragm on the telescope.
Sees that the remainder of the stores are handy for use.

(*c*) He supervises the preparation of stores

At preparation for action

3. **1** performs the following duties :—

(*a*) Ensures that the stores in para 2 above are correct and in position.

(*b*) Ensures that all bearing surfaces are clean.

(*c*) Levels the instrument.

(*d*) Focuses the telescope.

(*e*) Orients the instrument.

(*f*) Datums the instrument.

(*g*) Ensures that the telescope illuminating gear is correct.

(*h*) Tests the instrument if necessary.

(*j*) Supervises the work of the remainder of the detachment.

During action

4. **1** will :—

(*a*) Keep the crosswires of the telescope accurately laid on the bow waterline of the target.

(*b*) When the telescope is laid on the target, call " **On** " to **2** who calls the range to **3, 3** runs the transmitting dial to the range called by **2** and calls " **On range** " to **1**. **1** then reports " **On target** " to the **OPO**.

(*c*) Should **1** at any time lose the target, report " **Target lost** " to the **OPO**.

SECTION 7.—DUTIES OF 2

1. **2** watches the arrow on the slider and calls ranges to **3**, and applies initial ballistic and travel corrections to the correctional gear on the slider.

At preparation of stores

2. **2** performs the following duties :—

(*a*) Draws the illuminating gear and places the switch and resistance coils in position on the pedestal, or connects up gear illuminating with Transformer RA No. 6 Mark 1 in accordance with Handbook of Artillery Instruments and Range-finders Part 1 Sec 27 PF (all patterns), Amendment No. 1. **2** then places the electric bulbs in the sockets provided, one on the telescope and one on the slider.

(*b*) Assists **1** as ordered.

At preparation for action

3. **2** performs the following duties :—

(*a*) Ensures that the stores in para 2 above are correct and in position.

(*b*) Connects up the lamp battery.

(*c*) Tests the illuminating gear on the slider.

(*d*) Ensures that the hole in the object glass cap is clear and places the cap on the base plate of the instrument.

(*e*) Assists **1** as ordered.

During action

4. The duties of **2** are as follows :—

(*a*) When **1** has laid on the target and called " **On** ", **2** calls the range to **3.**

(*b*) **2** watches the arrow on the slider and calls ranges at intervals of 25 yards (or as ordered by the OPO).

(*c*) Whenever a correction is ordered **2** will call the range to the nearest 25 yards.

(*d*) If a correction is to be applied on the slider, **2** will repeat and apply it and report " **On** ".

(*e*) In the event of a correction being ordered which cannot be applied on the correctional gear, **2** will not apply any portion of the correction, but will report " **Scale full** ".

SECTION 8.—DUTIES OF 3

1. **3** operates the range transmitter or range indicator dial and applies range spotting corrections when ordered.

At preparation of stores

2. **3** draws the range indicator dial with box of numbers, and places the RI dial and the box of numbers in its allotted position.

At preparation for action

3. **3** performs the following duties :—

(*a*) Ensures that the stores in para 2 above are correct and in position.

(*b*) Sees that the range transmitter is properly connected up and that the terminal connections are secure. (Watkin transmission.)

(*c*) Connects up the dial battery and examines, cleans, and tightens all terminals. (Watkin transmission.)

(*d*) " **Test dials** " when ordered.

During action

4. The duties of **3** are as follows :—

(*a*) *Using Watkin transmitting dials " B " and " E ", Marks* 1 *or* 3 :—

(i) **3** runs the transmitting dial to the initial range called by **2** and reports " **On range** " to **1.** Thereafter keeps the hand of the transmitter dial reading the ranges called by **2.**

(ii) When the OPO orders a correction to be applied on the transmitting dials, **3** repeats it and turns the milled nut until the arrow mark points to the net correction on the correctional scale. **3** then makes the dial hand read the range called by **2** and reports " **On** ". The dial will then transmit DRF range ± net correction applied.

(iii) The hand of the dial is always to be kept reading the same range as the DRF.

(iv) In the event of a correction being ordered which cannot be applied on the correctional gear, **3** will not apply any portion of the correction, but will report " **Scale full** ".

(*b*) *Using dial, mechanical " E ", Mark* 2 :—

(i) **3** runs the figures in the " range slot " to the initial range called by **2** and reports " **On range** " to **1**. Thereafter keeps the figures in the " range slot " reading the ranges called by **2**.

(ii) On a correction being ordered by the OPO, **3** repeats it, locks the range handle and turns the appropriate correctional handle till the net correction appears in the " correction slot ". **3** then unlocks the range handle, puts on the range called out by **2** and calls " **On** ".

(iii) In the event of a correction being ordered which cannot be applied on the correctional gear, **3** will not apply any portion of the correction, but will report " **Scale full** ".

(*c*) *Using Magslip transmitting dial No.* 1, *Mark* 1 :—

(i) **3** runs the pointer on the range dial to the initial range called by **2** and reports " **On range** " to **1**. Thereafter keeps the pointer of the range dial reading the ranges called by **2**.

(ii) On a correction being ordered by the OPO **3** repeats it, applies it on the correctional dial and reports " **On** ", and then returns the friction pointer to zero and applies all subsequent corrections from zero.

(*d*) *Using the range indicator dial* :—

(i) **3** places on the range indicator the initial range called by **2** and reports " **On range** " to **1**, and continues to place on the range indicator the ranges called by **2**.

(ii) If ordered to apply a correction, **3** will repeat the correction, stand in front of the dial, apply the correction on the correctional disc by the ghost finger, bring the ghost finger to read the range called by **2**. **3** will then stand clear and call " **On** ".

(iii) In the event of a correction being ordered which cannot be applied on the correctional gear, **1** will not apply any portion of the correction, but will report " **Scale full** ".

CHAPTER 3

MANNING PARADE

SECTION 9—FORMATION OF THE DETACHMENT

1. On the order " **Fall in** " the duty watch detachment takes up position in front of the battery manning parade, together with any further OP detail as follows :—

3 2 1

CHAPTER 4

PREPARATION OF STORES

SECTION 10.—INSTRUCTIONS FOR SETTING UP THE INSTRUMENT

1. Before setting up the DRF ensure that the base plate is held rigidly on the pedestal. The locking plate should be in a position to receive the feet of the levelling screws.

2. Loosen the three bolts which clamp the locking plate and turn the plate until the larger openings in it are over the V-shaped slots in the base plate body. See that the V-shaped slots are free from grit or dirt.

3. Grasping the framework with both hands, carefully lift the DRF out of the box.

4. Place the toes of the levelling screws in the V-shaped slots of the base plate and rotate the locking plate so that it holds down the levelling screws.

5. Tighten up the three clamping bolts with the spanner. The bolts should be tightened sufficiently to prevent any possibility of the instrument lifting, but not so tightly that the levelling screws cannot be turned.

6. Open the Y-clips, remove the telescope from the box, carefully place it in the Y-brackets, close the Y-clips, and insert the coned keep-pins.

SECTION 11.—SELECTION OF EYEPIECE

1. The selection of the most suitable eyepiece is governed by the conditions of light and weather. The high power eyepiece is not so accurate as the low power eyepiece in hazy or misty weather, whereas in clear, or dull clear weather, the high power eyepiece should be used.

2. Tests should be carried out locally so that experience may be gained as to which power should be used under varying conditions.

3. To carry out the tests, each observer should take the range ten times to a fixed object. The range to the object need not be known. The test should be carried out with each eyepiece. Repeat the test on several days on different objects and under different atmospheric conditions. The objects chosen should approximate to normal fighting ranges.

4. The consistency figure for each series is found and these figures are used as a guide to the choice of eyepiece under varying conditions.

CHAPTER 5

PREPARATION FOR ACTION

SECTION 12.—POSITIONS IN ACTION

1 in rear of the instrument facing seawards.
2 on the left of the instrument facing the range slider.
3 at the transmitter dial.

SECTION 13.—PREPARATION FOR ACTION

1. On arrival at their positions in action the detachment carry out the following duties :—

(*a*) Duties of **1** :—

- (i) Cleans the bearing surfaces.
- (ii) Levels the instrument (Sec 14).
- (iii) If the instrument cannot be levelled **1** will carry out the tests laid down in Sec 34 and report any errors to the OPO.
- (iv) Focuses the telescope (Sec 15).
- (v) Orients the instrument (Sec 16).
- (vi) Datums the instrument (Sec 17).
- (vii) Tests the illumination of the crosswires. This should be done at day as well as at night preparation.
- (viii) Supervises the work of the remainder of the detachment.

(*b*) Duties of **2** :—

- (i) Ensures that the lamp battery is connected up and that the terminals are clean and tight.
- (ii) Examines the illuminating gear and ensures that it is properly connected up.
- (iii) Tests the illumination of the range scale.
- (iv) Assists **1** as necessary.
- (v) After the instrument has been levelled and datumed, **2** sets on the correction gear of the range slider the ballistic correction ordered by the OPO.

(*c*) Duties of **3** :—

- (i) Sees that the range transmitter is clean, ~~ansmitting~~
- ~~terminals~~
- (ii) Ensures that the transmitter lights come on when the power is switched on, ~~for use.~~
- (iii) Assists No. 1 when required.

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s soon as each number has completed preparation for action he will stand at ease at his position in action. The OPA will collect reports as laid down in Coast Artillery Training, Volume I, 1938, Section 124 (Amendment No. 4).

SECTION 14.—TO LEVEL THE INSTRUMENT

1. When an instrument has been levelled by a sensitive bubble the bubble is seldom found to have taken up a central position, but is slightly to one side. This is known as its "*zero of level*".

2. When levelling a DRF it is first necessary to find this position using the telescope bubble.

3. *To find the "zero of level"* :—

(*a*) With the correction gear at zero set the range arm slider to the nearest 1,000 yards to extreme range and the height drum to the corresponding correction for curvature and refraction (*see* Appendix II).

(*b*) The levelling screws will be numbered 1, 2 and 3.

(*c*) Bring the telescope bubble parallel to screws 1 and 2. To test this move screw 3. If the bubble moves, it is not parallel.

(*d*) Once the parallel position of the bubble has been found, a mark should be made on the wall of the OP in line with the axis of the telescope. Thereafter much time will be saved by laying the telescope on the mark instead of finding the parallel position by trial.

(*e*) Bring the telescope bubble level by turning screws 1 and 2 together, either inwards or outwards, according to the direction of adjustment required. Bring the cross body bubble level by means of levelling screw 3.

(*f*) Without moving the telescope, set the bearing scale to zero and clamp up. Turn the instrument through 180 degrees.

(*g*) If the bubble remains central the "*zero of level*" has been found. If the bubble is not central, bring it exactly half way back towards the centre by screws 1 and 2. Turn the instrument through 180 degrees and check. Continue this adjustment alternately at zero and 180 degrees until the bubble remains in the same position. This is the "*zero of level*". Note this position carefully as it may be the zero for subsequent tests.

4. *To complete the levelling :—*

(*a*) Turn the instrument through 90 degrees and bring the bubble to the "*zero of level*" by levelling screw 3.

(*b*) Check the level at every 90 degrees and the bubble should not move more than a quarter of a division from its "*zero of level*".

5. The pivot is then vertical and the body bubbles should be in the centre of their runs. If the body bubbles are not in the centre of their runs they should be adjusted subsequently by an artificer.

6. If it is found impossible to level the instrument it is probably considerably out of adjustment. The tests described in Sec 34 should, therefore, be carried out and a report made to the OPO.

SECTION 15.—TO FOCUS THE TELESCOPE

1. Lay the telescope on a well defined object at least 2,000 yards distant.

2. *Mark* 2* *instrument.*—Push in or pull out the eyepiece until the crosswires appear distinct and rack the object glass in or out by means of the focusing screw until a clear view of the object is obtained.

3. *Mark* 2** *instruments and upwards.*—Revolve the eyepiece by means of the knurled focusing ring until the crosswires and object appear distinct.

4. With both types of telescope, lay accurately on the object and move the eye up and down and sideways. The apparent movement of the crosswire should not exceed half its thickness. If the telescope is not in correct focus the crosswires will appear to move with the movement of the eye. In this

case the telescope must be re-focused until the crosswires appear to remain steady (or the apparent movement is within the stated limits) when the eye is moved.

5. The telescope should always be focused with the iris disphragm (where fitted) fully open.

SECTION 16.—TO ORIENT THE INSTRUMENT

Marks 2* and 2**

1. Loosen the bearing scale clamping screw and lay the vertical crosswire in line with the datum.

2. Keep the telescope laid on the datum and rotate the bearing scale to read the correct bearing. Tighten up the clamping screw and check the setting of the vertical crosswire.

Marks 2 to 5

3. Using the slow motion traversing gear, align the vertical crosswire of the telescope on the datum point. Loosen the two screws securing the skin of the minute drum and revolve the skin until the correct number of minutes of bearing is indicated. Tighten up the two screws.

4. Now turn the drum in an anti-clockwise direction until zero is reached.

5. Loosen the clamping screw and revolve the bearing degree scale until the correct number of degrees of bearing is indicated by the reader. Tighten the clamping screws.

6. The last two steps should be checked by laying back on the datum and on other datums where available.

SECTION 17.—TO DATUM THE INSTRUMENT

Instruction

1. Datuming is the process of adjusting the instrument for rise or fall of tide. It also allows for the variations from mean refraction, the personal error of the observer and collimation error.

2. The instrument is datumed at preparation for action and re-datumed at stated intervals throughout the day and whenever the standby range is varied. The datum point chosen for this purpose is that which approximates most nearly in range to the standby range ordered, provided visibility permits. The interval of time between datuming varies with the range of tide for the day at the station concerned. In all cases when the datum points are visible instruments are re-datumed for every alteration of one foot in the state of the tide. After datuming the height drum is set half a foot in advance so that the error in height above sea-level never exceeds half a foot.

3. By night, or when visibility does not permit the use of the short-range datum, the height drum of the instrument is similarly adjusted from tide gauges or tide tables, *ie*, it is adjusted at time intervals corresponding to every one foot alteration in tide and it is set half a foot in advance.

4. The following procedure is used each time the instrument is datumed in accordance with para 2 above :—

(*a*) Focus the telescope.

(*b*) Ensure that the slider is set to the correct datum range on the right-hand side of the instrument. Lay the instrument for line on the selected datum, check the orientation and correct it if necessary.

(*c*) Bring the horizontal crosswires on to the waterline of the datum by means of the height drum with a last motion of depression. Note the reading on the height drum. Repeat the process twice and take the mean of the three readings.

(*d*) To the mean height so obtained add half a foot if the tide is falling, or subtract half a foot if the tide is rising. Set the resultant height on the height drum.

5. The process of datuming described in para 4 above is carried out by the OP look-out, provided that the look-out is a trained range-taker, and on the clear understanding that the look-out is to perform the duties of **1** in the event of an action. If the OP look-out is not capable of carrying out the duties of **1** then, at the stated times, **1** will datum the instrument.

6. The process referred to in para 3 above can be carried out by any person capable of setting a height on the height drum.

SECTION 18 —CHOICE OF DATUMS

1. Datums should fulfil the following requirements :—

(*a*) Be at normal fighting ranges. A minimum of three datums is desirable.

(*b*) Be free from abnormal tide effects.

(*c*) If possible, be on or near suitable standby bearings.

(*d*) The line, observer to datum, should not pass close to land masses such as a hillside or cliff, nor pass over stretches of dried sand at low tide. These are likely to cause serious errors owing to abnormal refraction.

SECTION 19.—TIDE

1. In certain places it is impossible to provide suitable datums. In this case the state of tide must be known and applied as a correction to the height of the instrument above mean sea level.

2. From the nature of DRFs it would appear in theory that it should be possible to use them for determining the state of tide. It must be remembered, however, that the underside of the telescope arm is curved to compensate for curvature and a mean value for refraction. If, therefore, the value of refraction at the time the observation is made differs from the mean, the result will be incorrect. This will frequently happen, and as there is no ready means of determining the value of refraction at any moment, this method of finding the state of tide is unreliable. In certain circumstances, however, this method may have to be accepted.

3. In setting the height drum of a DRF for which no suitable datum exists or which cannot be seen, the order of obtaining the state of tide will be :—

(*a*) Applying the state of tide as found by datuming a neighbouring instrument.
(*b*) A tide gauge in the target area.
(*c*) A neighbouring tide gauge.
(*d*) A graph derived from the tide tables.

SECTION 20.—TIDE GRAPHS

1. To compile a tide graph a sheet of graph paper should be prepared showing the state of tide on the vertical axis and the time of day on the horizontal axis. Points should then be plotted on the graph to represent the state of tide at hourly intervals from the time of high water to the time of low water and from low water to the succeeding high water.

2. The state of tide at hourly intervals may be found by reference to the following rule ; although this rule is an approximation it is considered sufficiently accurate for practical purposes :—

(*a*) During the 1st hour after HW the tide falls 1/12 of the range of tide.
(*b*) During the 2nd hour after HW the tide falls 2/12 of the range of tide.
(*c*) During the 3rd hour after HW the tide falls 3/12 of the range of tide.
(*d*) During the 4th hour after HW the tide falls 3/12 of the range of tide.
(*e*) During the 5th hour after HW the tide falls 2/12 of the range of tide.
(*f*) During the period remaining before LW the tide falls 1/12 of the range of tide.
(*g*) The same proportional rate of rise holds good between low water and the succeeding high water.

3. The graph is completed by drawing a smooth curve through the plotted points and the approximate state of tide can then be read for any required time of day.

4. The state of tide is subject to considerable fluctuation as the result of atmospheric pressure and, particularly in narrow waters, *eg*, in estuaries, of the strength and direction of the wind. There may, therefore, be a considerable difference from the information predicted in the tide tables, not only in the range of tide, but also in the times of high and low water.

SECTION 21.—TO TEST DIALS (WATKIN TRANSMISSION)

1. *Test points*

Test points are governed by the nature of equipment the DRF is serving.

2. 6-*inch guns on Marks* 2 *to* 4 *mountings*

First test point 5,000 yards.
Second test point 10,000 yards.

3. 9·2-*inch on Mark* 5 *mountings*

First test point 7,000 yards.
Second test point 12,000 yards.

4. 9·2-*inch on Mark 6 mountings*

First test point 10,000 yards.
Second test point 15,000 yards.

5. *Procedure for testing dials Watkin transmission* (*short range*) :—

No.	Order	Action
OPO	**“ Test dials ”**	To DRF 3. OPA repeats to guns. DRF 3 sees that the transmitter is at stops, correctional gear at zero, handle in notch and current switch on. Setters for range connect up dials, set correctional gears to zero and switch on. Setters report to gun Nos. 1 **“ Dial connected up and reading . . . . ”**
DRF 3	**“ DRF ready to test dials ”**	
Nos. 1 of Guns	**“ Ready to test dials ”**	Repeated by OPA to OPO.
OPO	**“ Go to first test point ”**	DRF 3 works transmitter slowly away from stops. Setters report to gun Nos. 1 **“ dials working ”.** Guns Nos. 1 repeat to OPA.
OPA	**“ Dials working ”**	DRF 3 works transmitter quickly to first test point.
DRF 3	**“ First test point on ”**	
OPO	**“ No. . . . Read ”**	Setters report to gun Nos. 1 **“ Range . . . ”** Gun Nos. 1 report **“ No. . . . range . . . ”** to OPA. OPA repeats to OPO.
OPO	**“ Go to second test point ”**	Procedure is repeated as above as for first test point.
OPO	**“ Put on maximum add correction ”**	DRF 3 puts on maximum add correction and reports **“ Maximum add correction on ”.**
OPA	**“ No. . . . Read ”**	Setters report to gun Nos. 1 **“ Range . . . ”.** Gun Nos. 1 report **“ No. . . . Range . . . ”** to OPA. OPA repeats to OPO.
OPO	**“ Put on maximum drop correction ”**	DRF 3 puts on maximum drop correction and reports **“ Maximum drop correction on ”.**
OPA	**“ No. . . . Read ”**	Setters report to gun Nos. 1 **“ Range . . . ”.** Gun Nos. 1 report **“ No. . . . Range . . . ”** to OPA. OPA repeats to OPO.

No.	Order	Action
OPO	**" Dials correct, scales zero, go to range . . . "**	**DRF 3** goes to stand by range—reports **" On range . . . "**.

Note 1.—If, during the testing of dials, it is found that they are not working correctly the OPO will order to DRF 3 **" Stop. Dials not working. Check connections "**. DRF 3 switches off and carefully inspects the battery and dial connections, corrects any faults found and reports to the OPO **" Connections correct "**.

Note 2.—If the dials are in error at either test point, they will be corrected, returned to the test point on which they were previously correct, and the drill for testing dials continued from that point.

6. If the range shown by the receiving dials does not agree with that on the range transmitting dial, the OPO will order the current to be switched off, the range transmitter to be run to the range shown on the receiver dials, the current to be switched on and then the range transmitter to be run to the test point.

7. If the receiving dials on separate guns are not themselves in agreement the OPO will order the receiving dial which was incorrect to be disconnected, and the range transmitter and gun dial which were correct to run to the range shown on the disconnected dial. The disconnected dial will then be reconnected and the range transmitter run to the appropriate test point.

8. If the receiving dials are not in agreement and neither set of dials is reading the test point range, the OPO will order one of the receiving dials to be disconnected, the current to be switched off, and the range transmitter to be run to the range shown on the connected receiving dial. The OPO will then order the current to be switched on and the range transmitter to be run to the range shown on the disconnected dials. The disconnected dials will then be re-connected and the range transmitter run to the appropriate test point.

9. To disconnect a receiving dial the switch is set to " Off " by means of the cabinet screwdriver from the tray of stores. If the switch is not fitted the dial must be removed from its supporting bracket.

10. *Notes on testing and working of dials :—*

(*a*) The dials must not be taken to pieces, except by a qualified officer or instrument artificer.

(*b*) The flap on the transmitting dial is simply a means of switching current on or off. With the flap down the current passes from the positive pole of the battery to the positive terminal of the transmitting dial, goes out by lines 3 and 4 to the receiving dial, and returns by line 7 through the transmitting dial to the negative pole of the battery.

(*c*) If it should be found on working the transmitting dial, with range increasing, that the receiving dial is working with the range decreasing or *vice versa*, interchange lines 3 and 4 at the transmitting dial.

(*d*) If the transmitting dial is working two or more receiving dials and all the receiving dials are working in the wrong direction, interchange leads 3 and 4 at the transmitting dial. If only one receiving dial is working in the wrong direction, interchange leads 3 and 4 at the supporting bracket.

(*e*) The dials must all be made to read alike by bringing them back to one of the test points.

(*f*) Both transmitting and receiving dials are stopped at extreme range (with no correction applied). Care must be taken to prevent the transmitting dial being worked in such a way as to force the hand of the receiving dial against " Stops ".

(*g*) If the dials are found to be working unsatisfactorily, the receiving dials should be taken to the transmitting dial and each dial connected in turn to the transmitting dial by short leads and then tried again. If they then work satisfactorily, the fault will lie either in the cable or in the leads between the transmitting dial and the terminals of the supporting brackets.

SECTION 22.—TO TEST DIALS (MAGSLIP TRANSMISSION)

1. *Test points :—*

First	8,000 yards.
Second	13,000 yards.
Third	25,000 yards.

2.

No.	Order	Action
OPO	**" Test dials route . . . "**	DRF 3 sees that the correction scale is at zero and that the changeover switches are in position for the route ordered and reports **" Ready to test dials route . . . contact "**. Elevation layers or setters of guns see that the correction scales of receiver dials are at zero and report to their Nos. 1 **" Scales zero "**. Nos. 1 of guns see that changeover switches are in position for the route ordered and report to the OPA **" No. . . . ready to test dials route . . . contact "**. OPA repeats to OPO.
OPO	**" Switch on "**	DRF 3 switches on power supply and reports **" Switched on "**.

No.	Order	Action
OPO	**" Go to first test point "**	DRF 3 sets the transmitter to first test point and reports **" First test point on ".**
OPO	**" No. . . . Read "**	OPA repeats to guns. No. 1 of gun concerned reports to OPA **" No. . . . range . . . ".** OPA repeats to OPO.
OPO	**" Go to second test point "**	DRF 3 sets the transmitter slowly and smoothly to the second test point and reports **" Second test point on ".**
OPO	**" No. . . . report "**	OPA repeats to guns. No. 1 of gun concerned reports to OPA **" No. . . . range, working smoothly . . . ".** OPA repeats to OPO.
OPO	**" Switch off "**	DRF 3 switches off power supply and reports **" Switched off ".**
OPO	**" Go to third test point "**	DRF 3 sets transmitter to third test point and reports **" Third test point on ".**
OPO	**" Switch on alternative power "**	DRF 3 switches on alternative power supply and reports **" Alternative power switched on ".**
OPO	**" No. . . . read "**	OPA repeats to guns. No. 1 of gun concerned reports to OPA **" No. . . . range . . . ".** OPA repeats to OPO.
OPO	**" Dials correct—go to range . . . "**	DRF 3 sets transmitter to stand by range and reports **" On range . . . ".**
OPO	**" Switch off "**	DRF 3 switches off power supply and reports **" Switched off ".**

CHAPTER 6

DRILL IN ACTION

SECTION 23.—DRILL ON ALARM

1. On receipt of **" Observe "**, **" Take post "** or **" Alarm "** and the description of target :—

(*a*) **1** traverses the instrument on to the target, keeps the vertical crosswires on the laying point and adjusts the horizontal crosswires on to the water-line by means of the range slider. As soon as **1** is satisfied that the instrument is correctly laid **1** reports " **On** " and continues to follow the target.

(*b*) **2** on receipt of travel corrections repeats and applies and reports " **On** ".

(*c*) **2,** on hearing " **On** " from **1** begins to call ranges and reports " **Range opening/closing** ".

(*d*) **3** applies the ranges as called by **2** to the range transmitter, and as soon as **1** has the correct range set reports " **On range** ".

(*e*) **1** on hearing " **On range** " from **3** reports " **On target** " to the OPO.

(*f*) Should **1** at any time be off the target **1** will report " **Target lost** " to the OPO.

SECTION 24.—TO TAKE TRAVEL

1. Travel will be measured on the order " **Take travel . . . secs** " from the OPA :—

(*a*) The OPA takes up a convenient position from which he can read bearing and range.

(*b*) **1** reports " **On target** " to the OPA and follows the target.

(*c*) The OPA will note bearing and range and start his stop watch.

(*d*) At the end of the specified interval the OPA will report " **Up** ". **1** will cease to follow until the OPA has recorded bearing and range.

(*e*) The difference in bearing and range will be reported by the OPA to the OPO in the form :—

" Travel . . . secs, R/L . . . degrees . . . minutes add . . . (yards) "
drop

SECTION 25.—DRILL WHEN BLINDED BY HOSTILE SEARCHLIGHTS

1. *Searchlight exposed :—*

(*a*) **1** calls " **Beam** " and removes his hand from the milled head of the range slider.

(*b*) **2** places the perforated OG cap on the telescope.

(*c*) **1** brings the crosswires on to the searchlight by means of the height drum, transfers his hand to the milled head of the range slider and continues to follow, calling " **On** " when laid.

2. *Searchlight doused :—*

(*a*) **1** calls " **Clear** " and removes his hand from the milled head of the range slider.

(*b*) **2** removes the OG cap.

(*c*) **1** brings the crosswires back on to the water-line by means of the height drum, transfers his hand to the milled head of the range slider and continues to follow calling " **On** " when laid.

SECTION 26.—DRILL WHEN USING TRANSMITTING DIALS "B" OR "E" MARKS 1 AND 3

1. **1** follows the target, keeping the crosswires of the DRF telescope on the water-line of the laying point of the target.

2. **2** watches the arrow on the range slider and calls ranges at intervals of 25 yards (or as ordered by the OPO). When a correction is ordered he will call the range to the nearest 25 yards. If the correction is to be applied on the slider he will repeat the correction ordered and call "**On**", when he has applied it. In the event of a correction being ordered which cannot be wholly applied on the correctional gear he will not apply any portion of the correction, but will report "**Scale full**".

3. **2** may, in addition, perform the duties of **3** whenever the transmitting dial can be so arranged as to make it practicable for him to do so. In this case he will keep the dial reading the same range as the DRF. It is unnecessary for him to look continuously at the transmitting dial since each notch of the dial handle represents 25 yards.

4. **3** operates the handle of the dial until the mechanical pointer reads the range called by **2**.

5. When the OPO orders a correction to be applied on the transmitting dial **3** repeats it and turns the milled nut until the arrow mark points to the net correction on the correctional scale. He then makes the mechanical pointer read the range called by **2** and reports "**On**" :—

(*a*) The dial will then transmit :—
DRF range ± net correction applied.

(*b*) The mechanical pointer of the dial is to be kept reading the same range as the DRF.

(*c*) In the event of a correction being ordered which cannot be wholly applied on the correctional gear, he will not apply any portion of the correction, but will report "**Scale full**".

SECTION 27.—DRILL WHEN USING TRANSMITTING DIAL "E" MARK 2

1. The duties of **1** and **2** are as for Sec 26, 1 and 2 above.

2. **3** operates the range handle until the figures in the "**Range**" slot agree with the range called by **2**.

3. When the OPO orders a correction to be applied to the transmitting dial **3** repeats it, locks the range handle and turns the correctional handle until the net correction appears in the "correctional slot". He then unlocks the range handle, applies the range called by **2** and calls "**On**". In the event of a correction being ordered which cannot be wholly applied on the correctional gear, he will not apply any portion of the correction, but will report "**Scale full**".

SECTION 28.—DRILL WHEN USING RANGE INDICATOR DIAL

1. The duties of **1** and **2** are as for Sec 26 1 and 2 above with the exception that **2** cannot perform the duties of **3** in addition to his own.

2. **3** places on the RI dial the ranges called by **2.** If ordered to apply a correction, **3** will repeat the correction, stand in front of the dial, apply the correction on the correctional gear by the ghost finger, bring the ghost finger to read the range called by **2**, stand clear and call **" On "**. In the event of a correction being ordered which cannot be wholly applied on the correctional gear, he will not apply any portion of the correction, but will report **" Scale full "**.

3. When different corrections for sections or guns are required, and only one RI dial is in use, **3** will show on the RI dial the actual range called by **2** and the correction ordered will be transmitted to the setters at the guns by a method to be decided upon locally.

4. The following example illustrates the method of working with the RI dial :—

OPO **" Observe . . . Target . . . degrees "**.

1 **" On target "**.

OPO **" Add 100 "**.

2 **" Add 100 . . . On . . . Range 9,100 closing "**.

3 on hearing 9,100 called, sets it on the dials, steps clear and continues passing ranges as called by **2.**

OPO after observing fall of shot **" Drop 400 "**.

3 . . . **" Drop 400 "** stands in front of the dial and applies the correction ordered.

2 . . . **" 8,850 "**.

3 sets the ghost finger of the RI dial to 8,850, steps clear and calls **" On "**.

SECTION 29.—GENERAL

1. When the mechanical dials are used, ranges should be passed in steps of 25 yards, but if the range is altering rapidly the OPO will order the range to be called at greater intervals as may be necessary. With all natures of dials **3** will pass ranges by keeping the hand moving at such a speed that the dial will indicate at any moment the range found by the rangefinder. The hand should therefore arrive at a graduation the moment the corresponding range is called by **2.**

2. Gun difference or other individual gun corrections are usually applied on the movable face of the receiving dial.

3. The OPO spotting corrections will normally be placed on the correctional scale of the transmitting dial. Where it differs for the various guns or sections and dials mechanical " E ", Mark 2, are not being used, it may be put partially or wholly on the receiving dial, in addition to the individual gun correction already referred to, instead of on the transmitting dial. Care must be taken that the handle of a transmitting dial is not moved while the flap is being turned, or is vertical, except when necessary when testing dials. If this be done the dials will be thrown out of agreement and will require checking and correcting.

SECTION 30.—CHECK DIALS

1. This order will normally be preceded by the order " **Scales zero** ".
eg, OPO " **Scales zero—check dials** ".
OPA " **Scales zero—check dials** ".

2. **3** (after setting the correctional gear on the transmitting dial to zero) sets the transmitter to the nearest ~~1,000~~ thousand yards of range and reports " **Transmitter range . . .** ". amdt 1

3. Setters carry out the procedure for scales zero, and on the order from the OPA " **No. . . . read** ", the setter on the named gun reports " **No. . . . range . . .** ". If the ranges reported by the setters agree with those reported by **3**, the OPA reports to the OPO " **Dials correct** ", if not, he reports to the OPO " **Dials incorrect No. . . . range error ± . . . yards** ".

4. When using WATKINS transmission the OPO will correct the dials and when correct report " **Dials correct** " to No. 3 DRF and guns. At the conclusion of the checking the OPO will order corrections to be re-set if necessary.

SECTION 31.—CEASE FIRING

1. When using WATKINS transmission, OPO checks and corrects the dials if necessary and orders " **Go to stops** ".

~~2~~ 3. **1** covers up the instrument on its pedestal or replaces it in its box in accordance with orders received.

~~3~~ 4. **2** sets the correctional scale of the DRF slider to zero. If the instrument is to remain on its pedestal he assists **1** to cover it up, if not he assists **1** to replace it in its box.

SECTION 32.—TO GO TO STOPS (WATKINS)

1. The order " **Go to stops** " may be required :—

(*a*) When it is necessary for the transmitter to take over from another transmitter, such as a DPF, when " Stops " has been arranged locally as the taking over point, or

(*b*) at a practice battery where it is necessary to return stores for safety or care and maintenance.

2. In conditions as in para 1 (*a*) above, **3** places correctional gears at zero and runs the transmitter to " Stops " and reports to the OPO " **Transmitter on stops** ".

3. On receipt of the order " **Go to stops** " **3** takes all corrections off the transmitting dial, runs the dial to " Stops " and reports to the OPO " **Transmitter on stops** ". When the OPO has informed **1** that the receiving dials are at " Stops " **3** disconnects the dial battery.

4. Setter for range sets the movable face of the range receiving dial to zero and reports to the OPA as soon as the dial is at " Stops ". When the OPA has reported " **All dials at stops** ", the setter for range places the cover over the dial.

5. The OPA informs all concerned " **All dials at Stops** " when such is the case.

SECTION 33.—THE FORM IN WHICH BEARINGS AND RANGES WILL BE CALLED

Order or Report	Order as given
1. *Bearings :—*	
005 degrees	Zero zero five degrees.
010 degrees	Zero one zero degrees.
100 degrees 25 minutes ..	One zero zero degrees two five minutes.
240 degrees 40 minutes ..	Two four zero degrees four zero minutes.
295 degrees 05 minutes ..	Two nine five degrees zero five minutes.
305 degrees	Three zero five degrees.
360 degrees	Three six zero degrees.
2. *Ranges in yards :—*	
400	Four hundred.
825	Eight twenty-five.
1,000	One thousand.
1,600	One six hundred.
1,850	One eight fifty.
6,050	Six zero fifty.
10,000	One zero thousand.
10,050	One zero zero fifty.
20,625	Two zero six twenty-five
26,025	Two six zero twenty-five.

CHAPTER 7

SECTION 34.—TESTS OF DRFs MARKS 2*, 2**, 3, 4 and 5

1. When the instrument has been accurately adjusted it should, with normal use, remain in adjustment for long periods. Periodical tests must, however, be carried out to check the stability of the adjustments and thereby establish that the instrument is capable of accurate range-finding.

2. The following tests may be performed by DRF specialists. They should be carried out in the order given. All adjustments should be made by REME instrument artificers.

3. Before carrying out the tests and adjustments, ensure that the instrument is perfectly clean and firmly clamped to the base plate.

4. *Telescope tests.*—The following three tests ensure the optical, mechanical and bubble axes being parallel, so that when the bubble is in the centre of its run the optical axis is truly horizontal. The accuracy of these tests and adjustments is important as they will affect subsequent tests. The adjustments which are REME responsibility are shown in detail in the Handbook of Artillery Instruments and Range-finders, Part I, 1933, Section 17.

(*a*) *Collimation test*

The line of collimation must correspond with, or be parallel to, the mechanical axis of the telescope. The line of collimation is the path of the light ray which enters the telescope through the optical centre of the object glass, and which afterwards passes through the intersection of the crosswires. The mechanical axis is the line passing between the centre of the two bearing rings.

To test

Set the range slider to an extreme range. Open the " Y " bracket clips. Lay the intersection of the crosswires on some well defined object at least 2,000 yards distant, and accurately focus the telescope. The intersection of the crosswires should remain on the same point when the telescope is rotated through a complete revolution.

(*b*) *Eighth of a circle test* (Roll test)

The axis of the telescope bubble must be in the same vertical plane as the mechanical axis of the telescope.

To test

Roughly level the instrument. Open the " Y " bracket clips. Bring the bubble central by the height drum. Rotate the telescope about 30 degrees to either side of its normal position ; the bubble should remain central.

(*c*) *End-for-end test*

The axis of the telescope bubble must be truly parallel to the mechanical axis of the telescope.

To test

Open the " Y " bracket clips. By means of the height drum bring the telescope bubble central. Reverse the telescope end-for-end and replace carefully in the " Y " brackets. The bubble should again be central.

5. *Levelling or vertical axis test* and setting body bubbles central when the instrument is levelled.

The main pivot axis must be truly vertical and the body bubbles central when the instrument is levelled.

To test

Secure the " Y " bracket clips.
Roughly level the instrument.
Set the range slider to maximum range.
Set the telescope bubble parallel to two levelling screws.
Set the bearing scale to read " O " degrees.
Bring the telescope bubble central by means of the height drum.
Traverse the instrument through exactly 180 degrees ; the bubble should again be central.

If the bubble is not central, bring it central, half by the two levelling screws and half by the height drum.

Traverse the instrument back to " 0 " degrees, and if the bubble is not central, repeat the procedure until a central position is obtained.

Traverse the instrument to 090 degrees and, if necessary, bring the bubble central by the third levelling screw.

Check the level at 090, 180 and 270 degrees.

When the instrument is levelled the body bubbles should be central.

6. *Zero point and curvature and " Y " bracket test.*—When the correction for curvature and refraction for any range is put upon the height drum, the slider moved to read that range, and the telescope bubble brought to the centre of its run, the bubble must remain in the centre of its run when the slider is set at any other range, provided that the curvature and refraction correction for that range is set upon the height drum. This ensures that when the instrument is levelled the optical axis of the telescope is horizontal when the range slider is set to any range and the corresponding C and R is set on the height drum.

To test

Previous tests must have been accurately carried out.

Set range slider to extreme range (14,000 for Mark 5).

Set height drum to read the corresponding C and R, *ie*, —36 ·16 feet on the red graduations for 14,000 yards.

Bring the telescope bubble to the centre of its run by means of the capstan headed screws in the " Y " bracket.

Set range slider to half the range (7,000 yards).

Bring the telescope bubble central by means of the height drum.

The corresponding C and R reading (—9 ·04) should now be indicated on the height drum.

7. When the tests and adjustments have been made the instrument should be oriented.

CHAPTER 8

THE TRAINING OF RANGE-TAKERS

SECTION 35.—SCHEME OF TRAINING—GENERAL

1. Training should be arranged on progressive lines, leading up to the tests laid down in the syllabus.

2. Continuity of instruction is most important. Individual progress charts are essential for the officer in charge of the training, and the interest of those under training may be stimulated if the charts are kept on view and the results of the periodical tests published in orders.

3. All range-takers will be tested periodically, if possible not less than once a month. The officer supervising the test should enter the results in a range-taker's record book.

4. Proficiency in depression range-finding depends primarily on good co-ordination between hand and eye when following a moving target. The most common fault in depression range-finding is a lack of attention to the task in hand. This is due to the facility with which a certain initial proficiency can be attained, leading to carelessness of manipulation and a general lack of style in all subsequent work.

5. Range-takers should be organized as a class and the instructor should have first call on them for one hour a day for five days a week. Careful records of all series must be kept so that each man's progress may be recorded.

6. The following publication should be consulted :—

Handbook of Artillery Instruments and Range-finders, Part I, Section No. 17.

SECTION 36.—RULES FOR RECORDING

1. Unless all records are complete and above suspicion, they are useless. The following rules must be observed :—

(*a*) The operator must never hear the ranges called. When following a moving target he must not know when he is being recorded.

(*b*) All observations must be recorded.

(*c*) No series must be discarded.

(*d*) The instructor must check all analyses himself and keep a record of the men's progress.

2. A progress chart must be kept for every man, showing full details of training.

SECTION 37.—SYLLABUS OF TRAINING

1. Training is best divided into six stages :—

(*a*) *Stage I.*—Theory of range-finding ; application of the theory to the instrument. Description of the instrument. Accuracy to be expected.

(*b*) *Stage II.*—Levelling the instrument, focusing, datuming and finding the height of the instrument, using a datum at a known range. Calculating the height of the instrument from the height recorded at the DRF, OP and the state of tide ; orienting the instrument.

(*c*) *Stage III.*—Taking ranges to a stationary target. Determination of each man's error and " *consistency* ".

(*d*) *Stage IV.*—Taking ranges to a moving target. Determination of each man's error and " *consistency* ".

(*e*) *Stage V.*—Preparation for action. Drill for passing ranges, application of corrections, drill in action. Drill when blinded by hostile searchlights. Drill with range indicator dial.

(*f*) *Stage VI.*—Care and preservation. Composition and care of electric batteries, their faults and remedies. Tests of the instrument.

SECTION 38.—ANALYSIS TREATMENT AND INTERPRETATION OF RESULTS

1. The errors in range involve discrepancies which are due both to systematic and to accidental causes, and must be treated to separate them as far as possible, but this separation cannot be effected rigorously. The systematic variation of the errors in range with range is eliminated by reducing the errors in range to errors in seconds of apex angle. Errors in seconds are used in analysis.

2. A satisfactory criterion of the general " *accuracy* " of instrument and observer for one series is the " *mean error* " (or bias) in seconds. This is found by adding up the errors in seconds, giving to each the appropriate sign, and dividing the net result by the number of observations in the series.

3. The most satisfactory criterion of the steadiness or " *consistency* " (smoothness) of the range-taking during a series is the " *mean residual* ". Residuals are the differences between " *individual errors* " and the " *mean error* ". The " *mean residual* " is found by adding the residuals, irrespective of " sign ", and dividing the sum by the number of observations.

4. The " *average error* ", which is found by adding the errors irrespective of sign and dividing the sum by the number of observations, is the best criterion of the overall performance of instrument and observer.

5. The *bias* (or the mean error) " *mean residual* ", and " *average error* " for each series should be calculated.

6. The performance of DRFs differ according to the effective height above sea level ; it is convenient to reduce errors in yards to the corresponding angular errors in laying. This may be achieved by the following formula :—

$$n = \frac{6 \cdot 876 \times h \times \mathrm{R}}{r^2}$$

where n = angular error in seconds.

$6 \cdot 876$ = is a constant.

h = effective height in feet (allowing for curvature and refraction).

R = error in laying in yards.

r^2 = range in hundreds of yards squared.

7. The standards of depression range-finding are as follows :—

Consistency	5 seconds.
Accuracy	12 seconds.

8. *The following example illustrates the analysis of a series on a standing target :—*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Series and observation	Height on height drum	Effective height (ht-(c-r))	Known range	Observed range	Error in range	Residual in yards
1	139·0′	127·1	8025	8075	+50	20
2	139·0′	127·1	8025	8100	+75	45
3	139·0′	127·1	8025	8000	−25	55
4	139·0′	127·1	8025	8025	±0	30
5	139·0′	127·1	8025	8075	+50	20

$$\begin{array}{lrrl} & +175 & 170 & \\ & -\ 25 & \text{—} & \\ \hline & 5)+150 & 5)\ 170 & \\ \hline \text{Bias or mean error}= & +\ 30 & 34 & = \text{mean residual} = \text{consistency.} \end{array}$$

(*a*) *To convert to seconds :—*

$$\frac{6\cdot876 \times h \times \text{error}}{r^2} = \frac{6\cdot876\times127\cdot1\times30}{80\cdot25^2} = 4 \text{ seconds accuracy.}$$

$$\frac{6\cdot876\times127\cdot1\times34}{80\cdot25^2} = 5 \text{ seconds consistency.}$$

9. *The following example illustrates the analysis of a series on a moving target.*

See Handbook of Artillery Instruments and Rangefinders, Part I, 1933, Pamphlet No. 17, Chapter 6, Sections 3 and 6.

1	2	3	4	5	6	7	8	9
Series and No. of observations	Time of observation	Height on height drum	Effective height (ht—(c-r))	Calculated or known range	Observed range	Error in range	Error in seconds	Residuals in seconds
1	1120	139·0	132·2	6085	6100	+15	− 4	10
2	1122	139·0	132·2	6050	6000	−50	+13	7
3	1123	139·0	132·2	6020	5975	−45	+13	7
4	1125	139·0	132·3	5995	5975	−20	+ 5	1
5	1126	139·0	132·5	5970	5950	−20	+ 5	1

Remarks

1. *Curvature and refraction* is calculated from the formula $\cdot 1844 \left(\frac{R}{\cdot 1000}\right) 2$ = ft. using calculated ranges.

2. A nomogram as issued for the annual test of rangefinders may be used to solve col 8. *See* Handbook of Artillery Instruments and Rangefinders, Part I, Pamphlet 17, Chapter VI, para 13.

3. Col 8 to nearest second.

$$
\begin{array}{rrrrrrrl}
 & & +15 & & +36 & & 26 & \\
 & & -135 & & -4 & & — & \\
\hline
 & 5) & -120 & 5) & +32 & 5) & 26 & \text{Bias or mean error = accuracy = } +6''. \\
\hline
\text{Bias or mean error =} & & -24 & & +6'' & & 5'' & \text{Mean residual = consistency = } 5''. \\
\hline
 & & & 5) & 40 & & & \\
\hline
\text{Average error =} & & & & 8'' & & &
\end{array}
$$

The conclusions based on this series would be :—

(i) The " *accuracy* " of instrument and rangetaker is satisfactory.
(ii) The " *consistency* " of rangetaking is also satisfactory.
(iii) The " *average error* " shows an overall satisfactory performance.

CHAPTER 9

SECTION 39.—ELECTRICAL BATTERIES

Cell, Leclanché, C, Mark 1

1. This consists of a non-porous earthenware jar, containing the following elements : a cylindrical zinc plate, a carbon rod, a depolarizing agent of peroxide of manganese and an excitant of sal-ammoniac solution. The jar is painted round its upper edge with a band of coal-tar varnish to prevent *creeping* of the solution, and is 14 inches high and 6 inches in diameter. Fig 1 shows a section of the cell.

2. The zinc is amalgamated to prevent *local action*, and riveted and soldered to it is a flexible copper strip providing a means of connection to another cell, the strip and its junction with the zinc being covered with protective varnish. The carbon rod has a terminal attached to it through the medium of a lead alloy. The junction and head are protected with varnish. Twelve agglomerate blocks of manganese peroxide form the depolarizing agent and are mounted round the carbon rod in two tiers of six, being kept in position by twine, a covering of coarse canvas and four rubber bands. The canvas prevents the possibility of detached portions of the depolarizer from making direct contact with the zinc. The excitant consists of a saturated solution of sal-ammoniac, made up as described in para 5, the jar being filled to within 1½ inches of the top. The constants of a newly made up cell are, approximately, EMF 1·5 volts and internal resistance 0·2 ohm.

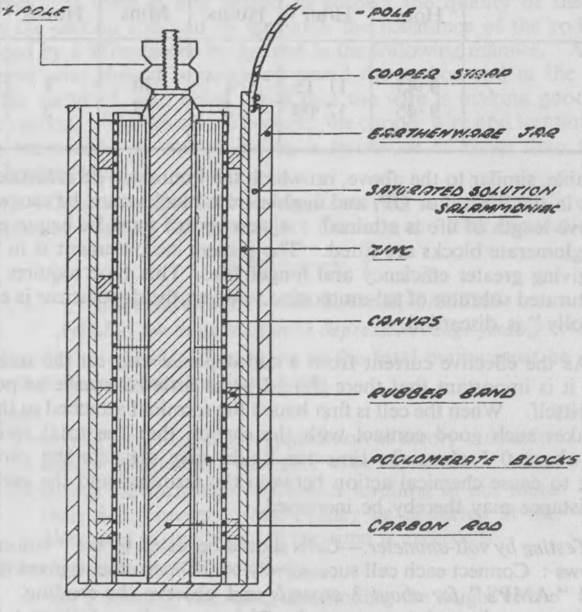

FIG. 1

Instructions for care, preservation, testing and renewing

3. Leclanché cells are greatly dependent for their effective action on the manganese in the agglomerate blocks. Special care must be taken, therefore, to ensure that the manganese in the blocks has not become exhausted and that the terminal contacts are good. A Leclanché cell, after a period of rest, will give an appreciable current, *for a short time*, even if the agglomerate

blocks are worn out, but this must not be mistaken for the working current of the cell. It is difficult to ascertain by any simple test when the agglomerate blocks are worn out, but, when a battery is working on a " position-finder " system, the life of the battery may be taken as :—

When working 1 set of dials	450 working hours.
When working 2 set of dials	225 working hours.
When working 3 set of dials	150 working hours.

4. **Table I—Leclanche cell log sheet**

Date	From-	To-	Hours worked		Total time worked to date	
	Hour	Hour	Hours	Mins	Hours	Mins
1.1.36	9·45	11·15	1	30	1	30
3.1.36	9·45	12·00	2	15	3	45

A table, similar to the above, on which the hours will be recorded, should be kept in the PF cell or OP, and agglomerate blocks must be renewed when the above length of life is attained. A new record must be begun each time new agglomerate blocks are fitted. The present sack element is in " dolly " form, giving greater efficiency and longer life. This type requires a 50 per cent saturated solution of sal-ammoniac. When the depolarizer is exhausted the " dolly " is discarded.

5. As the effective current from a cell depends also on the resistance in circuit, it is important that there should be as little resistance as possible in the cell itself. When the cell is first issued the terminal attached to the carbon rod makes such good contact with the carbon that the total resistance is small—about 0·1 ohm. In time the liquid may saturate the carbon rod, tending to cause chemical action between the terminal and the carbon, and the resistance may thereby be increased.

6. *Testing by volt-ammeter.*—Cells should be tested by the " volt-ammeter" as follows : Connect each cell successively to the instrument, press the button marked " AMPS " *for about* 3 *seconds* and observe the reading. Any cell not giving a reading of 4 amperes should be re-made as follows : Take the cell apart, removing the indiarubber rings and canvas. Soak the carbon rod and canvas in hot water until all adhering crystals are removed. Take new agglomerate blocks and a new carbon (if the resistance test shows that this is necessary), secure by means of four pieces of stout twine, re-wrap with canvas and secure with four indiarubber bands. The zinc plate should then be carefully washed (scraped with a piece of wood, if necessary) to remove any crystals and dirt. Make up a fresh saturated solution of sal-ammoniac,

as follows : Drop crushed sal-ammoniac into water until it is saturated. The process will be hastened if hot water is used, but on no account must the solution be poured into the cell until it is quite cold. Each cell requires about 1-lb of sal-ammoniac. The cell should now be tested as previously detailed. Each cell in an electric battery must be numbered by means of a piece of xylonite attached to the copper strip of the zinc plate. The cells will be numbered 1, 2, 3, etc, beginning with the cell at the positive pole of the battery. Each cell must be tested in the presence of an officer, at least quarterly, and a record of such tests will be kept.

7. The zinc plate of a cell will last a considerable time and may be considered efficient as long as it has not become " holed ". The copper strip may occasionally require to be renewed. It should be fastened to the zinc plate by a copper rivet. The copper strip may require repainting with black tar varnish. If there is any reason to suspect the quality of the contact between the carbon rod and its terminal, the resistance of the rod may be determined by a Wheatstone bridge test in the following manner. A piece of soft copper wire should be wrapped round the carbon rod at the opposite end to the terminal, care being taken that the wire is making good contact with the carbon. The resistance between the copper wire and terminal should then be measured. A carbon giving a resistance of more than 0·2 ohm should be rejected.

Note.—Great care should be taken in moving cells that the liquid is not spilt, as it is very liable to injure the cells and their connections.

APPENDIX I

EXAMINATION OF RANGE-TAKERS

Syllabus for examination in depression range-finding

1. In order to qualify, 75 per cent of the total marks must be obtained, with not less than 60 per cent, in any test.

2. Tests	Total marks
(*a*) Theory of range-finding—Application of theory ; description of instrument ; accuracy to be expected	10
(*b*) Levelling the instrument—Correct levelling in not more than five minutes ; (marks may be deducted at the discretion of the board if the time is exceeded) ..	15
(*c*) Setting up the instrument :—	
(i) Focusing, datuming and finding the height of the instrument, using a datum at a known range.	
(ii) Calculating the height of the instrument from the height recorded on the datum board and the known state of the tide.	
(iii) Orienting the instrument	15
(*d*) Finding the range to a stationary target—The range will be taken 12 times, and each reading recorded as accurately as possible. The series will be analysed	

	Total marks
as in Sec. 38. The error must be within the limit allowed, and the time for the series must be satisfactory to the board	*
(*e*) Following a moving target—The candidate will follow a target, at a suitable range. The target speed should be 10 knots, or more if possible. The procedure and method of analysis will be that described in Sec. 38. (Marks may be deducted at the discretion of the board.)	*
The board will note the steadiness of following in bearing. The candidate will forfeit up to 5 marks for jerky following	5
(*f*) Duties of 1, 2 and 3—Preparation for action, drill, passing ranges and applying corrections with range transmitter and range indicator dials	15
(*g*) Illuminating gear and batteries—Use of illuminating gear, testing Leclanché cells ; faults and their remedies	15
(*h*) Testing the instrument—Explanations of the tests	15
Grand total	90

* If the candidate is outside the limits allowed he fails the complete test.

APPENDIX II
VALUE OF CURVATURE AND REFRACTION

Range in yards	Corrections in feet	Range in yards	Corrections in feet
1,000	0·18	16,000	47·23
2,000	0·74	17,000	53·31
3,000	1·66	18,000	59·77
4,000	2·95	19,000	66·60
5,000	4·61	20,000	73·79
6,000	6·64	21,000	81·36
7,000	9·04	22,000	89·28
8,000	11·81	23,000	97·59
9,000	14·94	24,000	106·26
10,000	18·45	25,000	115·30
11,000	22·32	26,000	124·71
12,000	26·56	27,000	134·50
13,000	31·18	28,000	144·63
14,000	36·16	29,000	155·16
15,000	41·51	30,000	166·03

APPENDIX III

CARE AND PRESERVATION

1. Care must be taken that all terminals are screwed well home and that there is no dirt or insulating material between them and the wires. If the terminals are fitted with two nuts the first one must be screwed tightly on to the wire, and the second one tightly on to the first in order to lock it.

2. Instruments when used for instruction or practice will be in the immediate charge of a qualified officer or NCO and before passing out of his charge are to be carefully inspected.

3. On no account must an unqualified man attempt to set up or use a DRF or attempt to dismantle or adjust any parts.

4. All parts must be kept clean and dry. Dirt or verdigris must, on no account, be scraped off metal parts, neither must scouring soap or powder or similar substance be used for the purpose, but it should be removed with kerosine oil. If the lacquer or bronze on any part is worn off, that part should be relacquered or rebronzed. This must only be done by an artificer.

5. Steel parts and working surfaces should be oiled occasionally, but most of the oil must be removed, leaving only a thin film. An accumulation of oil is liable to cause particles of dirt to adhere to, and damage, the working parts. Bearing surfaces, pivots, etc, should be oiled occasionally.

6. The body of the telescope is cleaned as follows—Remove the telescope from the Y-brackets, rub it over lightly, first with an oily rag, then with a clean one. If the cap fits tightly, rub the inside (and the corresponding face of the telescope) with an oily rag, care must be taken to ensure that no oil gets on lens. When moving the telescope, great care must be taken not to burr its bearing rings, nor to let it come into violent contact with anything. The bearing parts of focusing tubes and eyepieces of aluminium telescopes should be smeared with vaseline, but care must be taken that grit does not accumulate on them.

7. If the leads are damp or coated with mildew or verdigris, they are to be cleaned. Positive and negative leads are distinguishable in that the positive are painted red and the negative black. If the insulation of any lead has become worn or damaged a new one is to be fitted without delay.

8. A form (AF G 805) will be kept in all OPs showing a record of the testing of the cells and electric batteries in use.

APPENDIX IV

INSTRUCTIONS FOR TRAINING AND EXAMINATION IN RANGE-FINDING

Officers

1. Commanding officers will ensure that all captains and lieutenants, RA, under their command are able to pass a practical examination in the range-finders forming part of the equipment of the battery, and are able to instruct their men accordingly.

Other ranks

2. (*a*) An establishment of range-takers will be maintained in each unit, suitable to the manning requirements of the range-finders allotted to the unit, including a suitable surplus (to be decided by the CCA or OC Coast Artillery) to replace casualties.

(*b*) A range-taker's book will be prepared and kept in all units. This book will show :—

(i) A nominal roll of range-takers.
(ii) Dates of qualification and requalification.
(iii) Results of periodical tests.

Training

3. Training should be arranged on progressive lines, leading up to the tests laid down in the syllabus. Continuity of instruction is most important. Individual progress charts are essential for the officer in charge of the training, and the interest of those under training may be stimulated if the charts are kept on view in the instructional rooms concerned. The competitive spirit may be further stimulated by publishing the results of the periodical tests in orders.

Tests

4. Tests are laid down in the drill book for coast artillery range-finders. All range-takers will be tested periodically, if possible not less often than once a month, under the supervision of an officer. The results of these tests and the marks obtained will be recorded in the range-taker's book.

Classification

5. (*a*) Classification will be held annually at a time appointed by the CCA or OC Coast Artillery. For the Territorial Army, this will normally be shortly before annual training in camp.

(*b*) It will be conducted by a regimental board consisting of a president and two members. When possible the president should be a field officer and an instructor in gunnery should be included on the board.

(*c*) The result of the annual classification will be entered on AF B 2672.

Skill-at-arms badges

6. Ranger-takers badges are authorized in Regulations for Army Trades and Employment, 1952. These badges may be worn by personnel who have qualified in accordance with Appendix I of this pamphlet.

Removal from the list of qualified range-takers

7. Range-takers who fail to re-qualify at the annual classification will be removed from the list of qualified range-takers. Range-takers may be removed from the list at any time at the discretion of the commanding officer, either for incompetence or for failure at a periodical test. If entitled to a badge they will forfeit it on removal from the list. The commanding officer will exercise his discretion as to when a disqualified range-taker shall be allowed to present himself for re-examination and restoration to the list.

NOTES